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The Five

Q's (Cues)

of the

U.S. GOSIP Testing Program

Dr. Jean-Philippe Favreau

Computer Systems Laboratory
National Institute of Standards and Technology
U.S. Department of Commerce
Gaithersburg, MD 20899

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Computer Systems Laboratory
National Institute of Standards and Technology
U.S. Department of Commerce
Gaithersburg, Maryland 20899, U.S.A.

Abstract

In order to assist the various Federal Agencies in procuring OSI products specified by the Federal Information Processing Standards (FIPS) 146-1, Government Open Systems Interconnection Profile (GOSIP), the National Institute of Standards and Technology (NIST) has developed the U.S. GOSIP Testing program. The program includes a comprehensive test policy and procedure that must demonstrates technical credibility, acceptability to both vendors and users, assurance of interoperability and provide a basis for international recognition of national testing. The U.S. GOSIP Testing Program includes the identification of abstract test suites, the development of method to assess means of testing, the setting up of a test laboratory accreditation program, a definition for the role of interoperability testing and the creation of publicly available registers. NIST is currently implementing a quality improvement system covering five key areas of the U.S. Testing Program to ensure total coverage of the GOSIP requirements, to provide useful information the general public can "trust" and remain attractive to vendors for both marketing and quality improvements in product development.

Keywords: U.S. GOSIP Testing Program, Open Systems Interconnection, conformance testing, interoperability testing, quality system.

1. INTRODUCTION

In August 1988, the National Institute of Standards and Technology[1] (NIST) published a *Federal Information Processing Standard* (FIPS) mandating, as of August 15, 1990, that Federal Agencies requiring new installations of computer communications equipment shall procure Open Systems Interconnection (OSI) protocols, in the form of the *Government Open Systems Interconnection Profile* (GOSIP, FIPS 146 and 146-1) [1,2]. Today, federal procurements for communications equipment require that computer communications products for which GOSIP functionality is specified shall adhere to the provisions of the NIST GOSIP Testing Program. In particular, GOSIP conformant products must appear on the *Register of Conformance Tested Products*. Interoperability must be demonstrated between different GOSIP product suppliers, specified in this request for procurement, directly to this agency or by recording entries on a register indicated by the NIST *Interoperability Test Service Register*.

One of the main consequences of these decisions has been to boost the OSI market. Indeed, the federal market represents an important group of customers whose needs and requirements influence the whole American market. As a result, OSI product suppliers are vigorously attempting to meet these needs, and many of them advertise the availability of OSI products. But, many federal customers are not familiar with this technology and do not want to invest without a guarantee that these products have an appropriate level of quality. In order to help federal customers, NIST decided to set up a comprehensive program that would insure that some minimum level of quality is met by any OSI product procured by the government. This has led to the design and implementation of the U.S. GOSIP Testing Program. This program addresses all the aspects of conformance and interoperability testing - from the identification of test specifications to the accreditation of laboratories and registration of products. One of the Program's contributions has been to define the meaning of *GOSIP compliance*; an expression which has been used extensively in the American technical press by many vendors without any real justification, and whose definition has plunged NIST into an arena where technical issues were, in many instances, surpassed by policy issues.

This paper presents an overview of the U.S. GOSIP Testing Program and NIST plans towards harmonization. Section 2 introduces the U.S. GOSIP Testing Program. Section 3 discusses the quality improvement that is integral to the program. Section 4 presents the outlook in the context of the global market. Finally, Section 5 describes NIST's involvement in the global harmonization effort.

2. THE U.S. GOSIP TESTING PROGRAM

In April 1989, sixteen months before the U.S. Government mandated the use of Open Systems Interconnection in procurement of new networks and major upgrades to existing networks, a large Federal Agency issued a procurement specification for a multi-year computer purchase, including a requirement to conform to the U.S. Government OSI Profile (GOSIP) [1]. The agency sought NIST's advice on GOSIP compliance, specifically: How can vendor claims of GOSIP compliance be substantiated? Our answers were far from convincing, and as a result, the agency, a voluntary user of GOSIP in advance of the OSI mandate, withdrew the requirement for GOSIP compliance.

Following this incident we analyzed the OSI testing situation and concluded that, unless the NIST acted, no credible means of substantiating GOSIP compliance would be available in time to support the August 1990 U.S. Government OSI mandate. Abstract Test Suites, where they existed, were fragmented and not publicly available. Although multiple suppliers of Means of Testing (MOTs) existed, no credible mechanism existed to assess MOTs against GOSIP requirements; no mechanisms existed to determine if one MOT was acceptable and another not. No program of evaluating and accrediting commercial GOSIP testing laboratories was in place. Numerous policy issues were unresolved, including requirements for first-party (self-testing) versus third-party (independent laboratory) testing and the role of interoperability testing was an open issue; no forum was foreseen for shaping policy.

2.1. Problem Recognition

[1] This work is a contribution of the National Institute of Standards and Technology and is not subject to copyright.

The recognition of the situation described above was a stimulus for our work on the U.S. GOSIP Testing Program. Problem recognition involves the acknowledgment that two different communities (vendors and users) have difficulty in trusting each other. This mistrust is partially due to the complexity of the OSI protocols. Indeed, the aim is to allow interworking of separately developed pieces of software and hardware. This technology relieves users of dependence on specific vendors. Today users are ready to purchase OSI products based on GOSIP (see Figure 1) and vendors offer GOSIP products. In this context, the problem can be described as follows:

- Vendors have difficulty convincing users that their products are compliant with GOSIP specifications. The vendor community is not in agreement on how to accomplish this task. Each company implements its own quality assurance program with different levels of complexity. As a result, their attitude may vary from a "trust me" attitude to the acceptance of a formal conformance and interoperability testing process.

- Buyers, including Federal Agencies, face the problem of installing and operating software and equipment developed by different suppliers. Business needs dictate heterogeneous systems and network component suppliers. In many instances, a large organization or company will be geographically distributed over several countries where similar products are not necessarily available. Buyers need assurances that the software/hardware bought from one vendor will effectively interoperate with similar products from another source.

2.2. Program Implementation

We defined the GOSIP Testing Program to permit Federal Agencies to substantiate claims of GOSIP compliance and to provide a forum for shaping GOSIP testing policy [5,6]. Our strategy has been to provide users with a list of OSI products which have been certified as having passed specific conformance tests, and have demonstrated instances of interoperability. This list can serve as the starting point for the user who may have other requirements such as performance, robustness, or security.

Figure 1: U.S. GOSIP Specifications

In order to implement our strategy, we developed a very comprehensive program that addresses all the aspects necessary to achieve our objective and minimizes duplication of tasks. The core of the Program is described in two documents entitled *GOSIP Conformance and Interoperation Testing and Registration* [7] which, after several iterations, became a NIST Internal Report NISTIR 4594 and the *GOSIP Product Registration Criteria* [10]. The program encompasses identification and selection of Abstract Test Suites (ATS), and Reference Implementations (RI), assessment of Means of Testing (MOT), audit and accreditation of laboratories, registration of GOSIP compliant products, identification and selection of Interoperability Test Suites, and identification of interoperability services. Each of these elements is briefly described in the following paragraphs.

Our first priority was the identification of ATSs covering functionality in GOSIP, mainly based on the Stable Implementation Agreements from the OSI Implementors Workshop (OIW) [14]. A public call for submission of test suites was issued. Test suites were reviewed, selected, and registered as the basis of GOSIP Version 1.0 and GOSIP Version 2.0 testing.

Registration of ATSs provides a basis to solicit and assess test systems (or MOTs). Two other elements are necessary to perform this task: precisely defined procedures and RIs of the protocols. The *GOSIP Means of Testing Validation* [8] and the *GOSIP Means of Testing Generic Test Plan* [11] define the relevant procedures and criteria for assessment of products designed to test OSI protocols. In order not to duplicate work, our choice has been to separate MOT assessment from the laboratory accreditation process. This separation eliminates the needs for a laboratory to provide quality assurance for MOTs; a situation which would result in redundant assessment of MOTs. An additional component necessary for MOT assessment is a reference implementation which is used to demonstrate that the tool is able to properly run the selected ATS. To be registered, an MOT must implement the appropriate ATS in a required breadth and depth, and must possess sufficient quality and maintainability as demonstrated by the software and documentation.

After an ATS is approved and a method of qualifying MOTs is established, GOSIP testing laboratories can be accredited through the National Voluntary Laboratory Accreditation Program (NVLAP), using technical and administrative procedures constructed jointly with the Computer Systems Laboratory (CSL) and NVLAP. The detailed laboratory accreditation procedures are described in the *GOSIP Testing Laboratory Accreditation Handbook* [9].

Although conformance testing is necessary to assess adherence to a standard and to detect software errors in protocol implementations, conformance testing does not guarantee interoperability among OSI products; and yet, interoperability is of utmost concern to users. Thus, while there is no consensus about its role, NIST believes interoperability testing is a necessary part of any OSI testing program. Our activities in this domain have focused on the registration of industry accepted interoperability test suites and services offering interoperability information.

The key to the GOSIP Testing Program is a set of publicly accessible registers maintained by NIST. Details concerning these registers are given in the *GOSIP Testing Registration Criteria* document [10]. To monitor and direct staged improvements in the deployed base of GOSIP products, NIST has established registers for:

- GOSIP Abstract Test Suites: this register identifies the test specifications that are to be used to test the OSI products.
- Protocol Information Conformance Statement: this register identifies the proformae that should be accepted by laboratories to verify the static compliance of OSI products to the GOSIP profiles. The vendor uses these proformae to make a statement about which capabilities have been implemented for given OSI products.
- Interoperability Test Suites: the register identifies the minimum interoperability test suites that must be employed by any interoperability service in order to become acceptable for registration.
- Reference Implementations: this register identifies the OSI products that NIST and JITC use to perform the dynamic evaluation of MOTs.
- Assessed Means of Testing: this register identifies the MOTs that have been approved by NIST. An MOT constitutes an implementation of an abstract test suite for a given protocol and test method.
- GOSIP Accredited Laboratories: this register identifies all the accredited laboratories that performed testing for the U.S. GOSIP Testing program.
- Laboratories Approved for MOT Qualification: this register identifies the accredited laboratories that can performed MOT assessment for the U.S. GOSIP Testing Program.
- Conformance Tested GOSIP Products: this register identifies the OSI products that have passed conformance testing in the context of the U.S. GOSIP Testing Program. To be compliant to U.S. GOSIP implies that the OSI product is in this register.
- Interoperability Testing Services: this register identifies the organization that can provide interoperability information to complement the conformance testing register. To be in this register does not imply any endorsement from NIST.

3. THE FIVE Q's OF THE U.S. GOSIP TESTING PROGRAM

NIST and its Agent, the Joint Interoperability Test Center (JITC) are upgrading the U.S. GOSIP Testing Program to reflect inputs provided by the quarterly GOSIP Testing meetings and discussions with the European Community and several accreditation bodies in Europe. NIST intends to improve this program to be a **leader in terms of quality**, to provide useful information **the public can trust**, and to be **attractive to vendors** for both marketing and production quality improvements.

NIST strives for continuous quality improvement in five key areas of the U.S. GOSIP Testing Program: Abstract Test Suites, Means of Testing, Laboratories, Product Registration, and Vendor Development Process.

3.1. Quality of Abstract Test Suites

NIST has implemented a system of quality improvement to obtain completeness and suitability of the abstract test suites (ATSs) and to guarantee transparency in test campaigns.

NIST's agent, JITC, will collect all the inputs (defect reports, unsuitable test cases) from accredited laboratories and from the OSI Implementors Workshop (OIW). JITC forwards these reports to the relevant ATS maintenance authority as well as to all the NVLAP laboratories to insure transparency in the test campaign (i.e., same defects known by all laboratories).

3.2. Quality of the Means of Testing

NIST has implemented a system of quality improvement to obtain completeness and suitability of the Means of Testing (MOTs) and to guarantee transparency in test campaigns.

NIST ensures that all MOTs are assessed exhaustively by approved, accredited laboratories. To date, NIST has approved two MOT qualification laboratories: JITC and ACERLI, France. Common procedures are being put in place to insure the same level of assessment and the same format for the "MOT Qualification Reports" based on the *GOSIP Means of Testing Generic Test Plan* [11]. Today, ACERLI's qualification scope includes only the File Transfer Access and Management (FTAM), the Manufacturing Message Specification (MMS), and the 802.4 protocols. JITC is also the MOT registration authority. JITC provides the MOT qualification reports to the MOT suppliers. The MOT suppliers are required to provide the relevant MOT Qualification Report to all their NVLAP laboratory clients. Moreover, JITC collects any new defect reports from the GOSIP accredited test laboratories. JITC consolidates these defect reports and provides them as feedback to the MOT suppliers. MOT suppliers are required to provide these new defect reports to their NVLAP laboratory clients. This system helps to achieve transparency in test campaigns and to facilitate harmonization of test reports.

3.3. Quality in the Laboratories.

All NVLAP accredited laboratories are expected to upgrade their procedures to be fully compliant with ISO Guide 25 and ISO 9002. The upgrade is required to enable technical harmonization between all laboratories worldwide, so that multilateral recognition of accreditation bodies becomes feasible.

This upgrade will occur via proficiency testing. In March 1993 all GOSIP laboratories will provide to NVLAP their updated procedures. The principle rule is to record everything that is done during a test campaign, and to do only what is recorded. After receipt of updated procedures, a monitoring visit will be scheduled by NVLAP assessors. When the NVLAP renewal visits occur, only laboratories that have these updated procedures fully in place will have their accreditation renewed.

NVLAP assessors for the U.S. GOSIP Testing Program will be required to have a more stringent training in quality procedures.

3.4. Quality of the Product Registration

JITC, as the Agent of NIST, is the Product Registration Authority. JITC has in place a comprehensive and high-quality test report review process. The objectives of this review are twofold: 1) the suitability of the products to the relevant profiles and 2) the guarantee that the laboratories perform to the level of quality required.

During this process, JITC verifies that all the documents provided by the vendors follow the procedures defined in ISO 9646 [3] and comply to the U.S. GOSIP Testing program requirements. Indeed, a test report must be comprehensive, complete, reliable. Some of the documents required include the Protocol Implementation Conformance Statement (PICS), Protocol Implementation eXtra Information (PIXIT), Protocol Conformance Test Report (PCTR), System Conformance Test Report (SCTR), Product Architecture Diagram, and Test Configuration Diagram. A block and wire diagram must be provided that includes: 1) a pictorial explanation of the product architecture which accurately depicts the product to be registered and 2) an explanation of the test configuration which accurately describes the software, hardware, and protocols used by each components of the product. Each test case executed must result in a behavior acceptable from the point of view of the relevant International Standards and Stable Implementation Agreements. When a test case does not behave as expected, the laboratory must demonstrate that no instance of non-compliance occurs and provide all necessary technical justifications and logging information.

3.5. Quality in the Vendor Development Process

Vendors that have been assessed for quality (i.e., ISO 9000) might be able to enter their status in the GOSIP Register Database. The plan would allow four status levels: *Unknown*, *ISO 9001*, *ISO 9002*, and *ISO 9003*.

ISO 9000 (*Quality Management and Quality Assurance Standards* [12]) focuses on the quality system in place in the vendor organization in various elements of the product life-cycle (i.e., design, development, production, final inspection and test, installation, and servicing). The Introduction Section of ISO 9000 states:

> *"A principal factor in the performance of an organization is the quality of its products or services. There is a world-wide trend towards more stringent customer expectations with regard to quality. Accompanying this trend has been a growing realization that continual improvements in quality are often necessary to achieve and sustain good economic performance.*
>
> *Most organizations - industrial, commercial or governmental - produce a product or service intended to satisfy a user's need and requirements. Such requirements are often incorporated in 'specifications'. However, technical specifications may not in themselves guarantee that a customer's requirements will be consistently met, if there happen to be any deficiencies in the specifications or in the organizational system to design and produce the product or service. Consequently, this has led to the development of quality systems standards and guidelines that complement relevant product or service requirements given in technical specifications. The series of International Standards (ISO 9000 to ISO 9004 inclusive) embodies a rationalization of the many and various national approaches in this sphere".*

At the time of registration, together with the PCTRs and SCTRs, vendors would be asked about the quality level of the vendor organization. JITC would require the proof of any claimed quality registration. The relevant ISO 9000 certification body would also be referenced. It is not the role of the U.S. GOSIP Testing Program to assess the quality and validity of these bodies.

This recognition of the quality in the Vendor Development Process is not yet implemented. It will require discussions with users and vendors before any decision is made.

4. HORIZON

NIST, via the U.S. GOSIP Testing Program, proposes a vision of a more *active* and *contributing* service to the user and supplier communities. The U.S. GOSIP Testing Program has established a partnership between groups of users and vendors, and the Federal Government whose purpose is to implement a comprehensive quality process by which 1) vendors are able to demonstrate and promote the quality of their Information Technology (IT) products and 2) users can obtain information they trust on IT products available and that fits their needs and wants. Moreover, this program expects to provide vendors with access to the world market. Indeed, one of the most visible efforts that NIST has made over this past two years has been on the international front. NIST has conducted extensive discussions with the European Community (EC) and its member states, with Canada, Australia, Korea, Taiwan, Republic of China, and Japan, to understand the IT world market and help U.S. vendors to access foreign markets. To emphasize the importance of this activity, the author referred the reader to a paper published in The Journal of European Business, "Setting the Standards: How U.S. Testing Labs Can Influence EC Standards Development" [13]. This paper describes how regulations within the EC might serve as barriers to free trade between the EC and other parts of the world. While the example presented has nothing to do with OSI, many of the topics discussed are applicable to this technology.

This partnership between users, vendors, and the U.S. Federal Government is now taking a much broader scope with the introduction of the Industry Government Open Systems Specification (IGOSS). Today, NIST partners include the Manufacturing Automation Protocol (MAP), the Technical and Office Protocol (TOP), the Electric Power Research Industry (EPRI) user groups, and the Canadian Government. Discussions are ongoing that could result in the addition of the Federal Aviation Administration (FAA). The U.S GOSIP Testing Program is on its way to become the IGOSS Testing Program. There is little doubt that the IGOSS Testing Program will become the foundation of the North American OSI Testing Program.

In order to meet IGOSS Testing requirements, the U.S. GOSIP Testing Program plans to upgrade its procedures and include new testing capabilities. These procedures will reflect the scope of IGOSS and the views and concerns of NIST's partners. Moreover, NIST intends to continue to discuss any issues with vendors via the Open Systems Environment Implementors Workshop (OIW). These new technologies will include the Message Handling System 1988 (MHS), Transport Class 2, Integrated Services Digital Networks, Frame Relay, Fiber Distributed Data Interface (FDDI), Network Management, Manufacturing Message Specification (MMS), Directory Services (X.500), and Transaction Processing protocols. NIST will add any of these protocols to the Testing Program as soon as all the necessary components are identified (i.e., profiles, PICS, PIXIT, ATS, MOT). Some technologies will be added as early as the first quarter 1993.

5. HARMONIZATION EFFORT

The quality and strengths of the U.S. GOSIP Testing Program put NIST in an excellent position to achieve harmonization. This Section presents some specific areas where NIST expects tangible results.

One of the key technical problems that creates barriers to harmonization has been the design of regional solutions. Indeed, while ISO has provided an international forum for the specification of OSI protocols, the three open systems workshops have made regional decisions on how to implement OSI products. Such activity is unfortunately necessary and results from ambiguous and incomplete specifications. This process has resulted in U.S. GOSIP which is different from U.K. GOSIP. Different solutions are not desirable and not acceptable. This places a burden on the vendors that must follow, understand, and implement these solutions. The trend is now to harmonize the different regional solutions and to move to International Standard Profiles (ISPs). This

harmonization is independent from the Testing Program, but will provide a boost to NIST efforts. NIST expects more involvement and help from vendors across the world to pressure for testing harmonization.

The most important element necessary to set up a testing activity is the availability of Abstract Test Suites (ATSs). The EC has invested an enormous amount of funds to help the development of ATSs. The U.S. has not been able to match the European effort. NIST recognizes the outstanding work performed in Europe and has promoted the use of the resulting ATSs. The Testing Program intends to provide some level of support in the maintenance of these ATSs and, in certain areas, to contribute to the design of new ATSs. The quality system in place in the GOSIP Testing Program will allow NIST, with contributions from the laboratories and the OIW, to review the ATSs, and provide defect reports and solutions to the European maintenance authorities. Discussions are underway between the Open Systems Testing Consortium (OSTC) and NIST to facilitate this activity.

The Testing Program has set up a comprehensive Means of Testing (MOTs) qualification process. This process is unique in terms of scope and focus toward quality. NIST believes this process will allow a substantial improvement of MOTs and contribute to the European effort in this area. NIST and OSTC have started discussions intended to eliminate differences in the MOTs qualification process. Today MOTs are assessed in Europe following the OSTC and NIST procedures. This duplication puts some burden on the MOT suppliers. NIST hopes these discussions will result in an accomodation with OSTC which will allow the two processes to be technically equivalent and provide the same level of quality in their results.

The most important element necessary to achieve mutual recognition of test results relies on mutual-recognition agreements between the various national accreditation bodies. In the United States, the National Voluntary Laboratory Accreditation Program (NVLAP) is the entity responsible for the accreditation of IT laboratories. Two major steps towards the realization of mutual-recognition agreements between NVLAP and its EC counterparts have been achieved this part year. First, NVLAP has participated in a European project to develop the *Interpretation of Accreditation Requirements as Specified in ISO/IEC Guide 25 for Information Technology Test Laboratories for Software and Communications Testing Services* [15]. This document provides a common understanding of the requirements for IT laboratories between the EC accreditation bodies and NVLAP. NVLAP plans to integrate this document in its procedures as soon as it is approved by the European Committee for IT Testing and Certification (ECITC) and the Western European Laboratory Accreditation Cooperation (WELAC). Second, NVLAP is conducting a process that will result in an upgrade of its procedures to be fully compliant with ISO Guide 25 and ISO 9002 (see Section 3.3). This alignment with international requirements will remove the major barriers to mutual-recognition agreements. With these two major steps, NVLAP will be at the same level as its European counterparts for IT. By March 1993, all technical barriers will be removed. At that time, the United States will be able to test whether Europe has the political will to reach any agreement or whether European policies result in defacto trade barriers with the rest of the world.

In the United States there are two registration/certification schemes in place: the U.S GOSIP product registration scheme and the COS Mark. Today the COS Mark is being fully aligned with GOSIP Testing requirements. NIST and JITC are working on a document that will define how any COS Mark Product can automatically be added to the U.S. GOSIP Register of Conformance Tested Products. These procedures will be reciprocal and defined in such a way that there is a guarantee that the quality of NIST/JITC Registration Process is maintained. From NIST point of view, this document has a much broader scope than only the COS Mark. This document constitutes the vehicle by which agreement with any other certification schemes could be achieved. Before any progress can be made with foreign certification/registration schemes, a mutual-recognition agreement must be in place between NVLAP and the relevant foreign accreditation body (ies).

NIST is open to comparable discussions with other global regions to assist global harmonization of technical requirements.

6. CONCLUSIONS

NIST has put in place a strong and high quality testing program with the help of the user and vendor communities. Today the program covers most of the protocols mandated in GOSIP Version 2. More than 30 test tools have been assessed and registered, 15 laboratories have been accredited to conduct OSI testing, more than 70 products have passed the registration process, and 2 interoperability services have been registered (e.g., PSI and OSINET).

The largest challenge barring our path to open systems is the need to manage change. Changes to the base standards, implementor agreements, procurement specifications, products, tests, and test systems must be synchronized. Major inhibitors to such synchronization abound. For most base standards a companion set of standard tests are not defined. Implementor agreements are not yet fully coordinated world-wide and, of course, no globally agreed upon set of tests exists. A large number of procurement specifications exist world-wide: a good indication of market potential, but a possible source of market fragmentation. Remarkably, interoperable OSI products exist from a significant set of computer vendors.

Moving ahead will take a coordinated, global investment from a variety of sources: users, vendors, and governments, working together to create a common good. The challenge is to direct our investment for the highest quality, the highest productivity and the largest return. How can we answer the challenge?

The need of internationally agreed standard profiles is clear. With three regions of the world making implementation agreements and with government sector procurements throughout the world requiring OSI, the penalty for unnecessary divergence is a market fragmentation that bodes ill for the prospects of international interoperability and for the potential of an integrated, open world market for information technology (IT) products and services. The jobs of product development, test system creation, and operational deployment become more difficult, more expensive, and less beneficial, as the diversity among standards increases.

The benefits of uniform testing requirements are apparent. If a vendor can build a product, test it once, and then have the product and test results accepted throughout the world, the cost of product development will be significantly reduced. Thus, we need to produce a set of tests, test methods, and testing procedures that will be accepted around the world. We at NIST believe the first window of opportunity for aligning OSI testing requirements between the U.S. and Europe comes now, when we have a quality testing program in place for U.S. GOSIP Version 2.0. Our message is that an alignment must occur, if we are to achieve the benefits of uniform testing requirements.

Finally, the buyers of the world must, to the extent possible, agree on a set of procurement specifications, including testing requirements, that are consolidated, giving IT product vendors a large incentive to hit the mark. A fragmented market weakens the case for an investment in standard products and encourages competition among powerful interests to set de facto IT standards. Where de facto standards rule, the buyers invest in such standards through product purchases, trusting the dominant vendor to manage the evolution of the standards. Reliance on a dominant supplier may have a high price. How can we persuade users to invest in the public standards process, if we cannot make a convincing case that we are prepared to manage change?

As a final thought, looking ahead, we must remind ourselves that, even having met the technical and management challenges, international trade and integrated economies are entangled in a web of political and economic considerations that sometimes, rightly or wrongly, supersede other issues, and obstruct our way forward. We must carry our message to the policy makers in corporations and governments. Technical solutions must be in place, if our message is to be clear and convincing.

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